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# THEORY OF SUPERCONDUCTIVITY

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ACADEMIC PRESS INC., PUBLISHERS

New York, 1952

## CHAPTER 1

### Fundamental Facts

(a) Superconductivity was discovered in 1911 by Kamerlingh-Onnes.<sup>1</sup> He was the first to liquefy helium and so to produce temperatures below  $10^{\circ}\text{K}$ . With this new technique he was able to observe the continued decrease of the electrical resistance of metals with decreasing temperature. With mercury, in contrast to other metals, he was astonished to find that the resistance completely vanished, almost discontinuously, at about  $4.2^{\circ}\text{K}$  (Fig. 1-1). Today superconductivity is known in 18 other metals (see Table 1-1) whereas in others, e. g., gold and bismuth, the conductivity remains normal far below even  $1^{\circ}\text{K}$ . Many alloys and compounds can also become superconducting, in particular the frequently used niobium nitride which has a transition temperature as high as  $20^{\circ}\text{K}$ . However, among these latter substances hysteresis phenomena mentioned in the "Introduction" are so much more strongly evident that in testing the present theory we prefer to employ only the "good" superconductors, i. e., the pure elements.

In the ideal case the resistance vanishes completely and discontinuously at a transition temperature  $T_s$ . Actually the resistance-temperature curve does fall more sharply the more the specimen is like a single crystal and the smaller the measuring current used. Because the drop always occurs in a measurable temperature range, the experimental definition of the transition temperature is to some extent arbitrary. The temperature at which the direct-current resistance reaches one half of the value it had just before the drop is generally given as the transition temperature, because this can be measured accurately. However, a high-frequency investigation to be described in Chap. 16 (f) indicates that the foot of the curve where

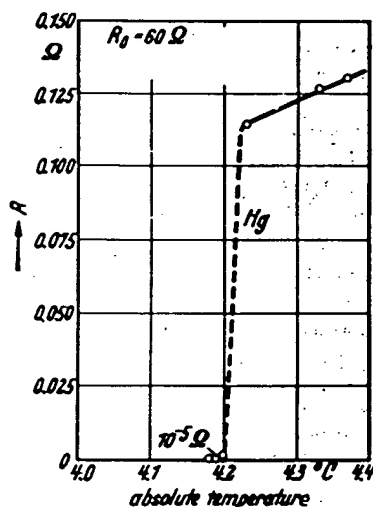


Fig. 1-1. Appearance of superconductivity in mercury according to H. Kamerlingh-Onnes (1911). The ordinate is the resistance  $R$ ;  $R_0$ , the resistance of solid mercury extrapolated to  $0^{\circ}\text{C}$ , is 60 ohms.

<sup>1</sup>H. Kamerlingh-Onnes, *Commun. Leiden*, 120b, 122b, 124e, (1911).